Labs21 2003 Annual Conference

Overcoming Barriers To and Taking Advantage Of Manifold Exhaust Systems

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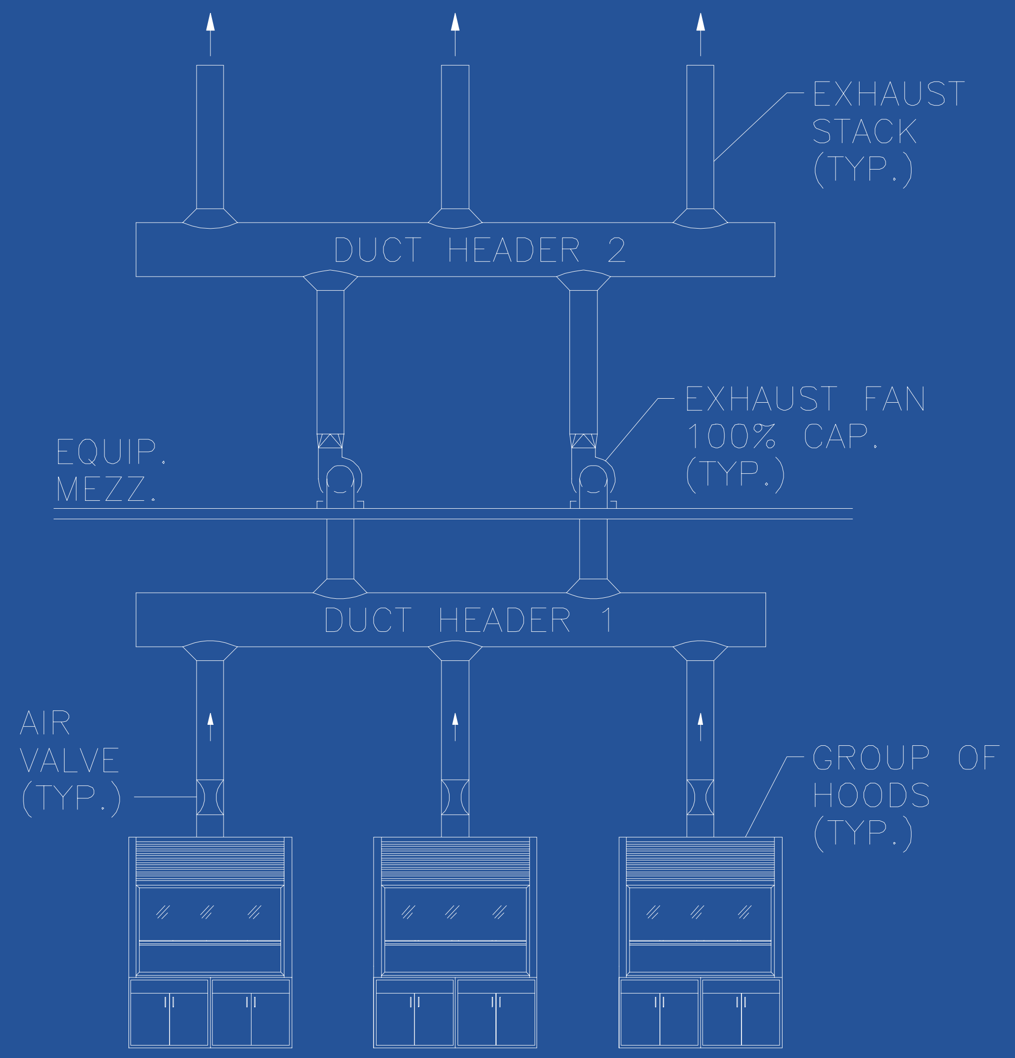
Labs21 Design Approach

- Adopt Energy and Environmental Performance Goals.
- Assess Opportunities From a "Whole Buildings" Approach.
- Use Lifecycle Cost Decision-Making.
- Employ a Broad Range of Sustainable Energy and Water Efficiency Strategies.

What is a Manifold Exhaust System?

- Combines individual exhaust streams into a common header.
- Employs two or more central exhaust fans with N+1 redundancy.
- VFDs offer energy savings at low utilization.



Barriers to Manifold Exhaust Systems

- Code Issues.
- ANSI Standard Z9.5 Compliance:
  - Maintain 3,000 fpm discharge velocity through entire range of operation.
- Assumed Cost Implications (ductwork).
- Functional Limitations - Will it work?
- Non-conventional.

Code Issues

- Definitions:
  - "Hazardous exhaust systems shall be independent of other types of exhaust systems."
  - "Incompatible materials, as defined in the *International Fire Code*, shall not be exhausted through the same hazardous exhaust system."

Source: 2000 International Mechanical Code

Code Issues

- Definitions:
  - "INCOMPATIBLE MATERIALS. Materials that, when mixed, have the potential to react in a manner which generates heat, fumes, gases or byproducts which are hazardous to life or property."

Source: 2000 International Fire Code

A Hazardous Exhaust System Is Required. . .

". . .wherever operations involving the handling or processing of hazardous materials, in the absence of such exhaust systems and under normal operating conditions, have the potential to create one of the following conditions:"

1. A flammable fume in concentrations exceeding 25% of the LFL of the substance.
2. A fume with a health hazard rating of 4 (any concentration).
3. A fume with a health hazard rating of 1, 2 or 3 (concentrations exceeding 1% of LC_{50}).

Source: 2000 International Mechanical Code

Evaporation Rate Calculation

$$W = \frac{MW \times K \times A \times P_{vap}}{R \times T} \qquad DC = \frac{W}{Q}$$

$$K = 0.00438 \times U^{0.78} \times (18/MW)^{1/3}$$

W	Evaporation rate [lb/min]
MW	Molecular Weight [lb/lb-mole]
K	Gas-phase mass transfer coefficient
A	**Surface area [ft^2] (1 ft^2)**
P_{vap}	Vapor pressure [psia]
R	Ideal gas constant [psia x ft3 / ◦R x lb-mole]
T	Temperature [◦R] (based on 68 ◦F)
U	**Air velocity [mph] (100 fpm)**
Q	**Airflow through hood [lb/min] (350 cfm)**
DC	Diluted Concentration [%]

Source: Estimating Releases and Waste Treatment Efficiencies for the Toxic Chemical Release and Inventory Form (EPA, 1987)

Flammability Quantification

Chemical	LFL	25% LFL	Diluted Conc.	Factor of Safety
Acetone	2.5%	0.625%	0.0080%	78
Acetonitrile	3.0%	0.750%	0.0026%	284
Benzene	1.2%	0.300%	0.0032%	95
Cyclohexane	1.3%	0.325%	0.0046%	71
Ethyl Acetate	2.0%	0.500%	0.0032%	155
Ethyl Ether	**1.9%**	**0.475%**	**0.0288%**	**16**
Heptane	1.1%	0.263%	0.0036%	72
Hexane	**1.1%**	**0.275%**	**0.0111%**	**25**
Isopropanol	2.0%	0.500%	0.0015%	333
Methanol	6.0%	1.500%	0.0029%	521
Methylene Chloride	13.0%	3.250%	0.0060%	540
m-Xylene	1.1%	0.275%	0.0005%	557
o-Xylene	0.9%	0.225%	0.0004%	625
Pentane	**1.5%**	**0.375%**	**0.0367%**	**10**
Petroleum Ether	1.2%	0.300%	0.0015%	194
Pyridine	1.8%	0.450%	0.0005%	858
Toluene	1.1%	0.275%	0.0010%	271

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Source: 2000 International Mechanical Code

Degrees of Hazard

Degree of Hazard	LC_{50} Criteria for Gases (ppm)	LC_{50} Criteria for Mists (mg/L)
4	$LC_{50} \leq 1,000$	$LC_{50} \leq 0.5$
3	$1,000 < LC_{50} \leq 3,000$	$0.5 < LC_{50} \leq 2$
2	$3,000 < LC_{50} \leq 5,000$	$2 < LC_{50} \leq 10$
1	$5,000 < LC_{50} \leq 10,000$	$10 < LC_{50} \leq 200$
0	$LC_{50} > 10,000$	$LC_{50} > 200$

Source: NFPA 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response (1996 Ed.)

Chemical Lethal Toxicity Quantification

Chemical	Acute Inhalation Toxicity LC_{50} ppm	LC_{50} mg/l	Degree of Hazard	Diluted Conc./ LC_{50}
Acetone	16,000	-	0	n/a
Acetonitrile	**7,551**	**27**	**1**	**0.38%**
Benzene	**16,000**	**32**	**1**	**0.51%**
Cyclohexane	-	70	1	0.25%
Ethyl Acetate	20,000	-	0	n/a
Ethyl Ether	20,000	-	0	n/a
Heptane	25,000	-	0	n/a
Hexane	48,000	-	0	n/a
Isopropanol	12,000	-	0	n/a
Methanol	64,000	-	0	n/a
Methylene Chloride	14,400	-	0	n/a
m-Xylene	5,000	-	2	0.10%
o-Xylene	5,000	-	2	0.07%
Pentane	-	364	0	n/a
Petroleum Ether	**3,400**	**658**	**2**	**0.45%**
Pyridine	4,000	-	2	0.13%
Toluene	8,000	-	1	0.13%

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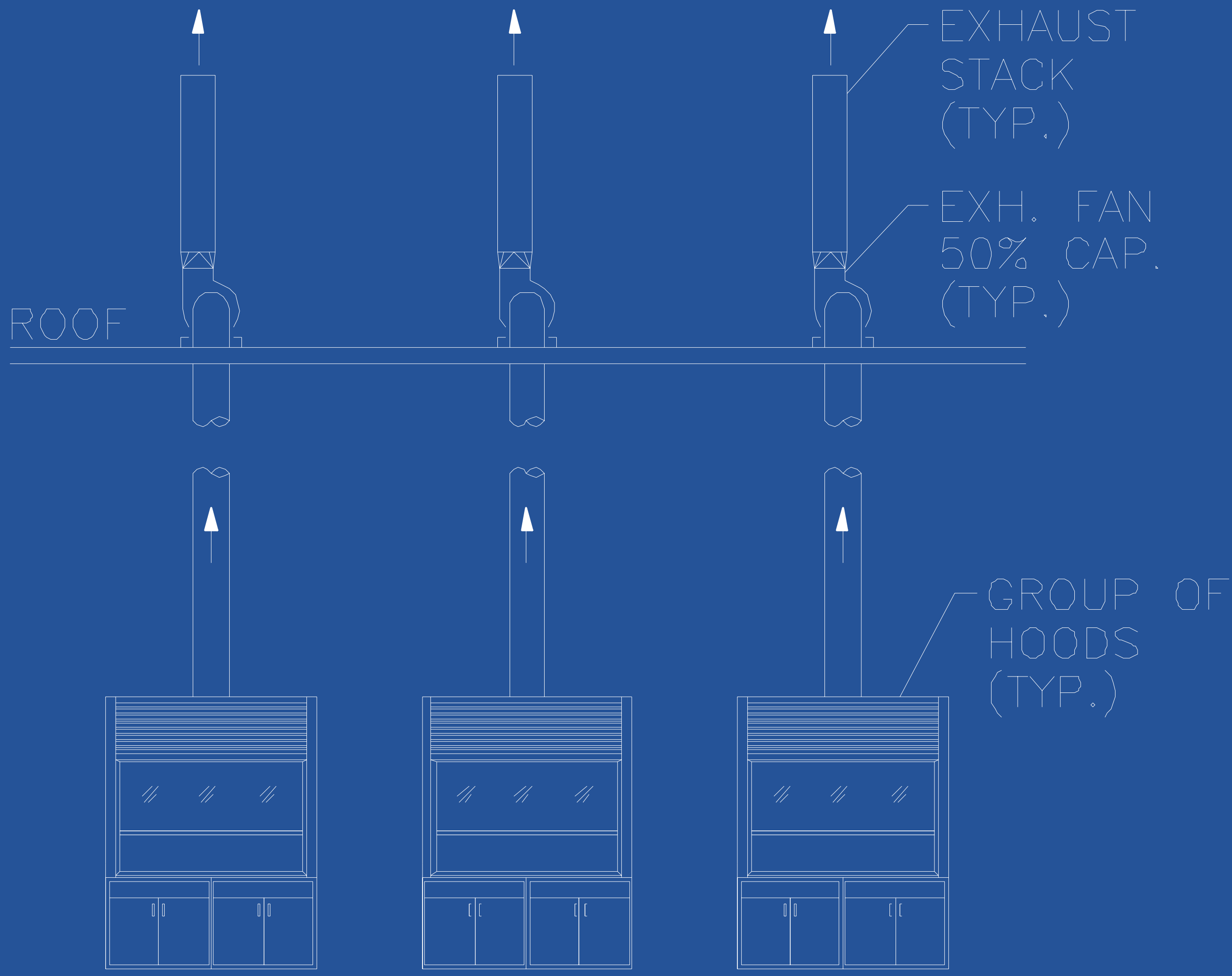
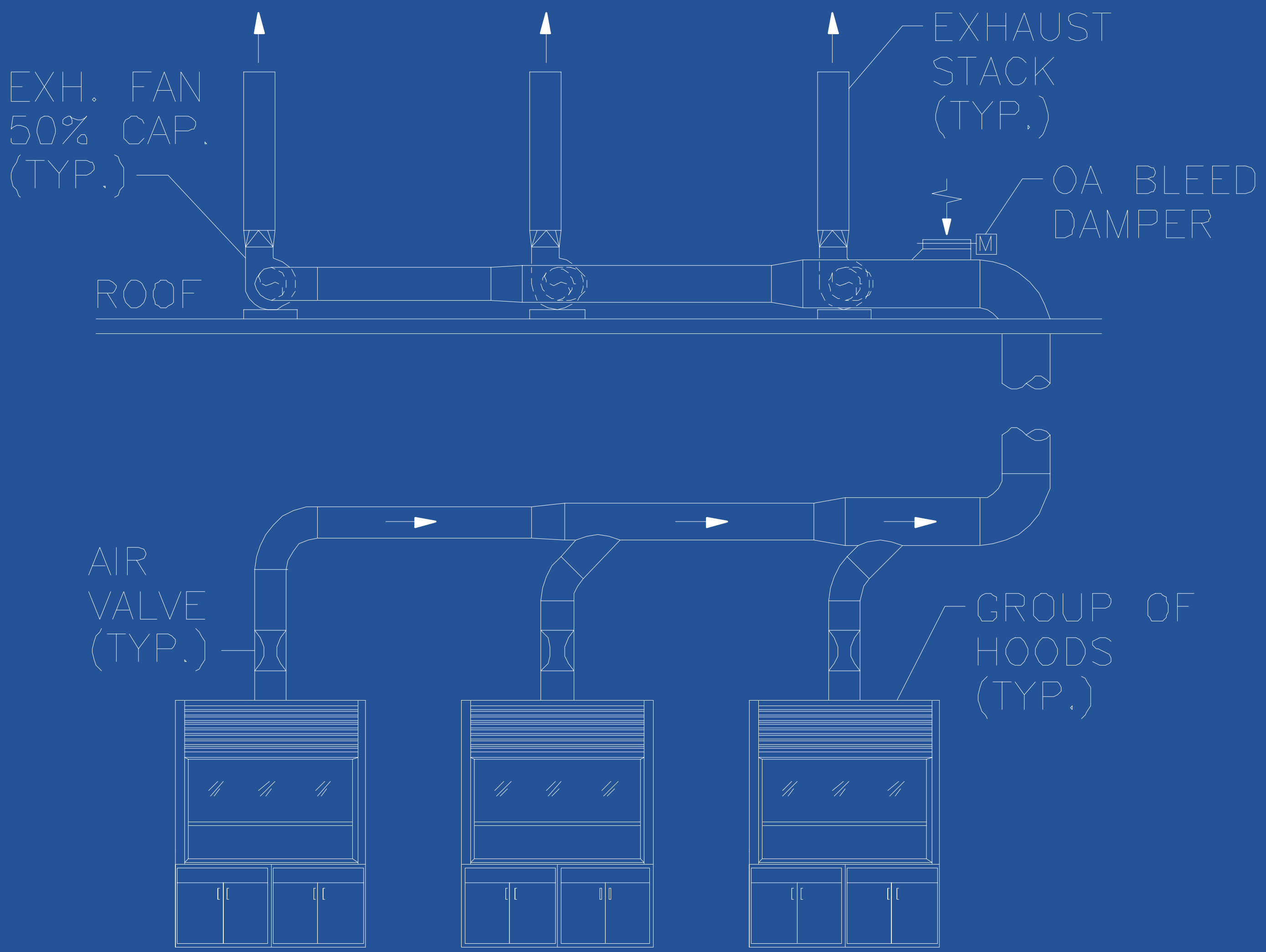
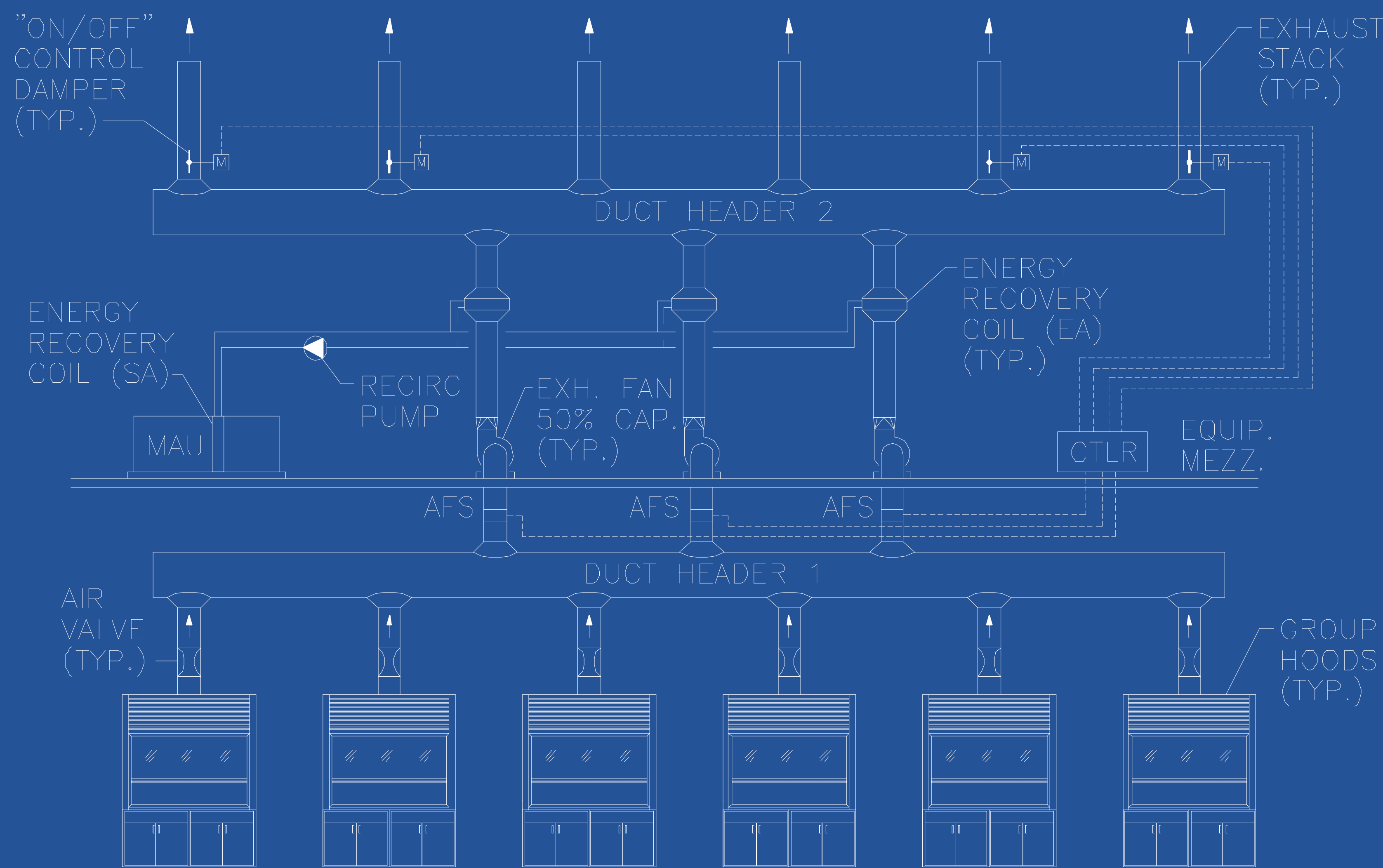
Typical Individual Fume Hood Exhausts



Manifold Exhaust with Outside Air Bypass



Manifold Exhaust with Energy-Saving Upgrades



IDC

03PE-9006
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IDC Patent - Stack Discharge Control Damper

- Velocity is measured at stack discharge by sensor 120.
- Controller 122 adjusts damper position to maintain minimum velocity (e.g. 3,000 fpm).
- Discharge geometry promotes laminar flow, thus optimizes plume height.

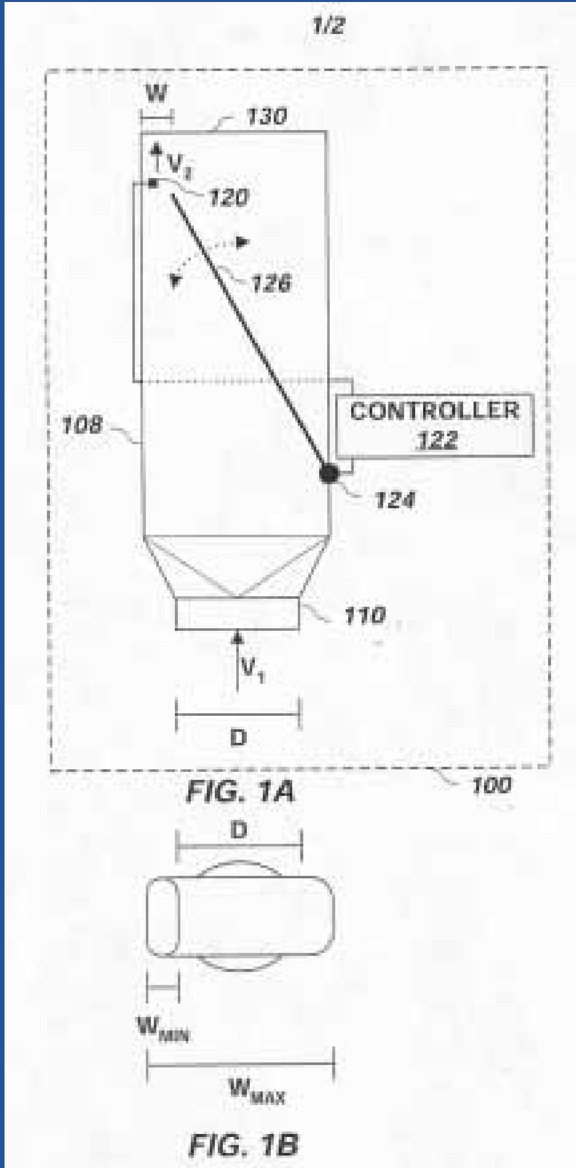
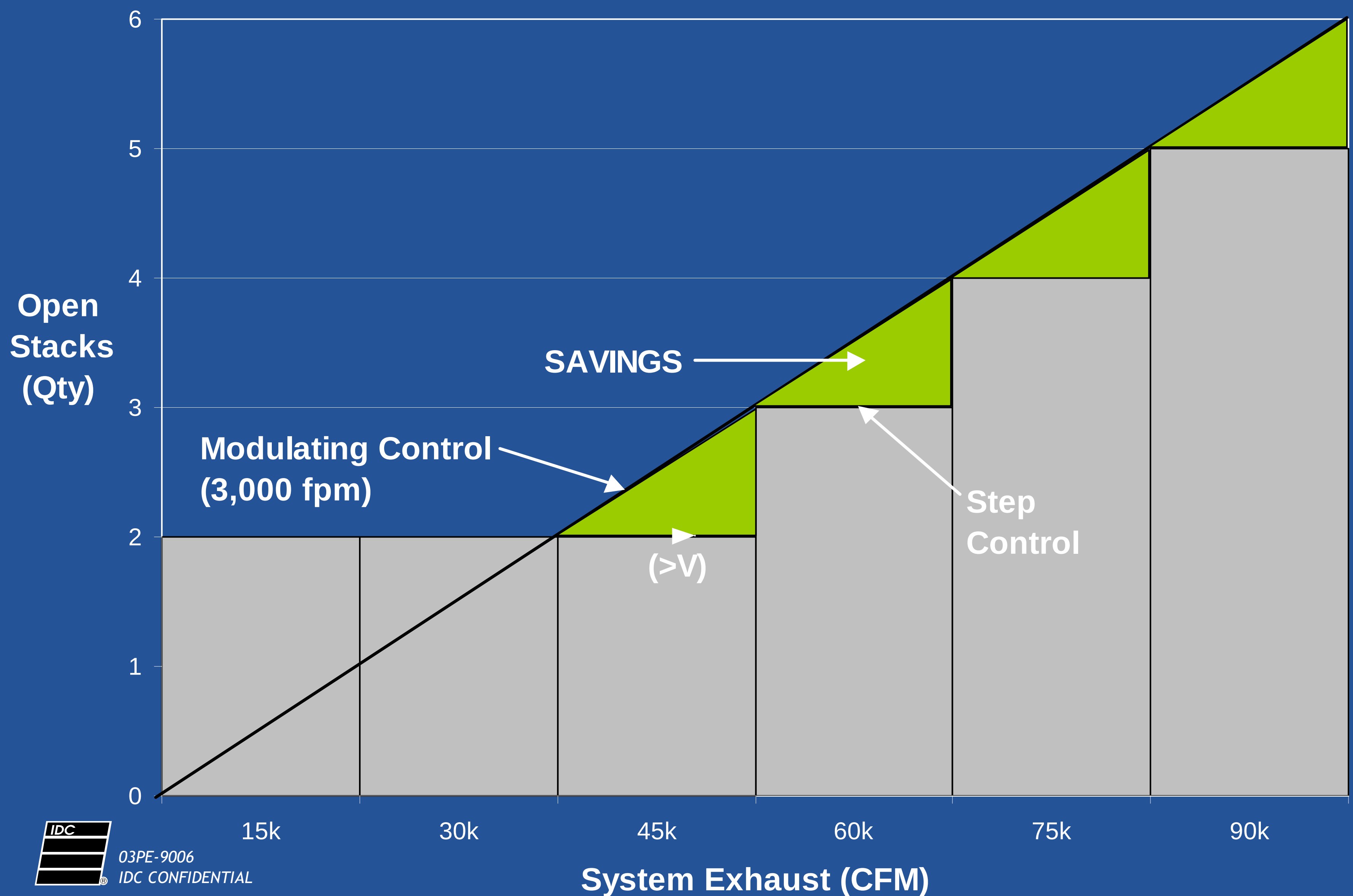


FIG. 1A

FIG. 1B

"On/Off" Dampers vs. Modulating Dampers



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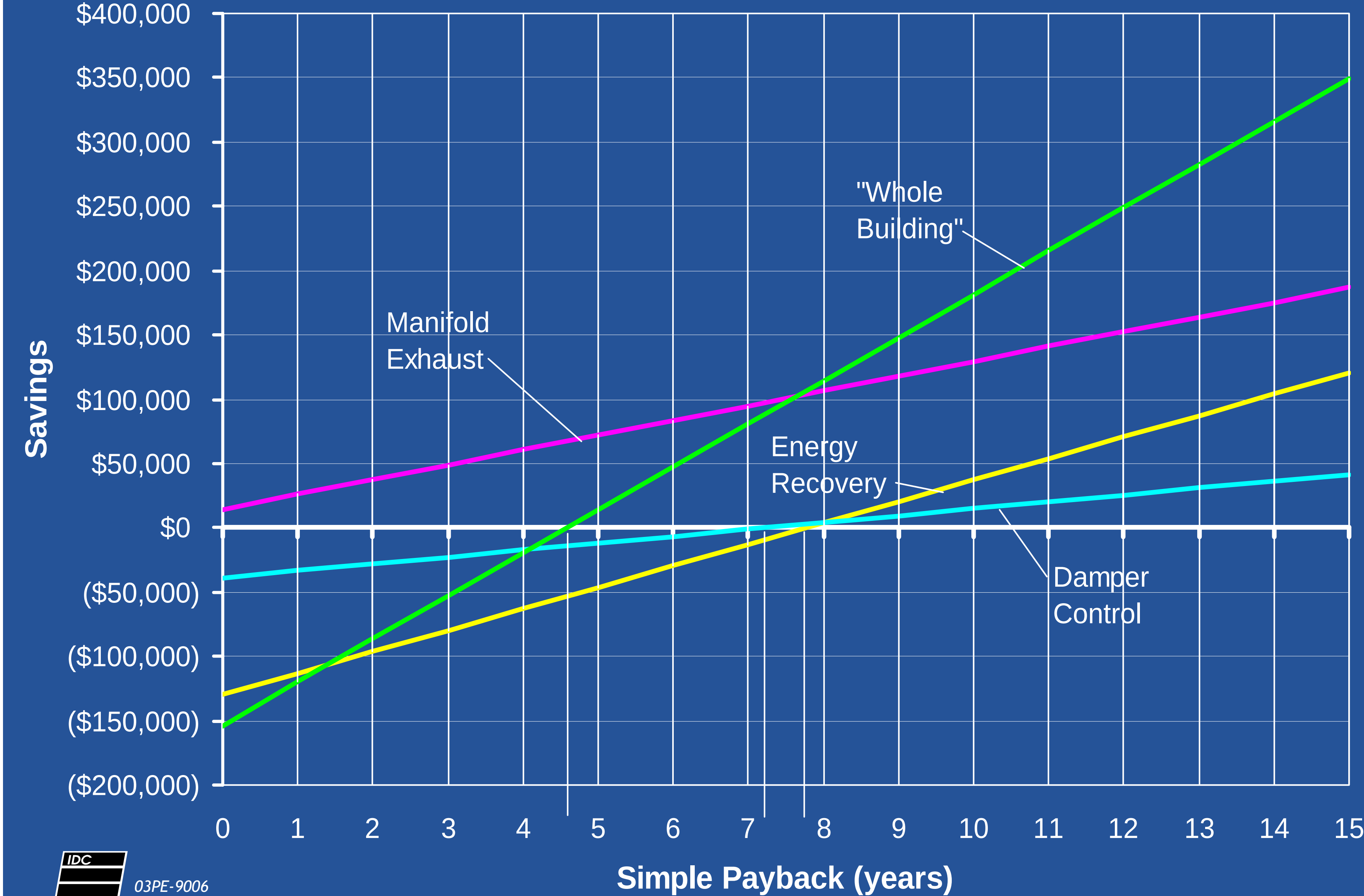
"Whole Building" Approach

- A manifold exhaust system offers an opportunity to bundle upgrades such as energy recovery and discharge damper control to maximize annual energy savings.
- LEED™ (Leadership in Energy and Environmental Design) encourages a "Whole Building" approach in design and identifies synergies between LEED™ credits.

"Whole Building" Savings and Payback



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Benefits of Manifold Exhaust Systems

- Lower installation cost - fewer fans.
- Lower operating cost - VFDs.
- Reduced concentration in duct - dilution.
- Reduced maintenance - fewer fans to service.
- Redundancy - backup fan.
- Offers facility flexibility - future tie-ins.
- Emergency power simplification - fewer fans.
- Aesthetics - consolidate exhaust stacks.
- Reduced roof penetrations - fewer stacks.
- Reduced stack height - Higher mass flow rate.

Thank You . . .

BENEFITS OF MANIFOLD EXHAUST SYSTEMS SHOULD BE CONSIDERED ON YOUR NEXT PROJECT!